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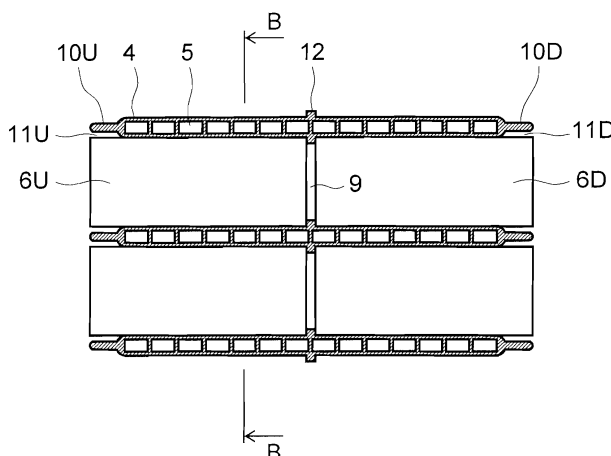
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(54) **HEAT EXCHANGER**

(57) In a parallel-flow-type heat exchanger, heat efficiency performance is improved and smooth drainage of defrost water and condensed water is achieved. A heat exchanger (1) has horizontal header pipes (2) and (3) arranged parallel at an interval from one another in the vertical direction, vertical flat tubes (4) arranged at an interval from one another in the horizontal direction between the header pipes (2) and (3), with vertical refrigerant passages (5) provided inside the flat tubes communicating with the insides of the header pipes, and cor-

rugated fins (6) arranged between the flat tubes (4). The corrugated fins (6) include upwind-side corrugated fins (6U) whose fin surface has a downward slope toward the downwind side and downwind-side corrugated fins (6D) whose fin surface has an upward slope toward the downwind side. On the side faces of the flat tubes (4), vertical ribs (12) are formed with which the downwind-side ends of the upwind-side corrugated fins (6U) and the upwind-side ends of the downwind-side corrugated fins (6D) are kept in contact.

FIG.3



Description

Technical Field

[0001] The present invention relates to a parallel-flow-type heat exchanger.

Background Art

[0002] A parallel-flow-type heat exchanger having a plurality of flat tubes arranged between a plurality of header pipes, with refrigerant passages inside the flat tubes communicating with the insides of the header pipes, and with corrugated fins arranged between the flat tubes, is widely used in car air conditioners and the like. Examples are seen in Patent Documents 1 and 2.

[0003] The heat exchanger described in Patent Document 1 has a plurality of header pipes arranged horizontally, and has a plurality of flat tubes arranged vertically, and corrugated fins between the flat tubes are shaped like valleys with their bottom at a central part of the heat exchanger in the depth direction. At the valley-bottom part of the corrugated fins, where they join the flat tubes, through holes are formed; when defrosting operation is performed to melt frost sticking to the heat exchanger, the water resulting from the frost melting is drained through the through holes.

[0004] Patent Document 2 describes a heat exchanger in which a plurality of tongue-like pieces are cut to raise from one and the opposite faces of the flat-plate part of corrugated fins, with a view to increasing heat exchange efficiency at the corrugated fins.

[Patent Document 1] JP-A-2005-24187

[Patent Document 2] JP-A-2001-66083

Disclosure of the Invention

Problems to be Solved by the Invention

[0005] An object of the present invention is to improve the shape of corrugated fins to achieve improved heat efficiency performance in a parallel-flow-type heat exchanger. Another object is to achieve smooth drainage of defrost water and condensed water.

Means for Solving the Problem

[0006] To achieve the above objects, according to the present invention, a heat exchanger comprises: a plurality of horizontal header pipes arranged parallel at an interval from one another; a plurality of vertical flat tubes arranged with a predetermined pitch between the plurality of header pipes, with vertical refrigerant passages provided inside the flat tubes communicating with the insides of the header pipes; and corrugated fins arranged between the flat tubes. Here, the corrugated fins comprise upwind-side corrugated fins whose fin surface has a downward slope toward the downwind side and down-

wind-side corrugated fins whose fin surface has an upward slope toward the downwind side. Moreover, the downwind-side ends of the upwind-side corrugated fins and the upwind-side ends of the downwind-side corrugated fins are kept in contact with ribs formed on the side faces of the flat tubes.

[0007] With this structure, owing to the fact that the upwind-side corrugated fins have a downward slope and the downwind-side corrugated fins have an upward slope, the length over which the upwind-side corrugated fins and the downwind-side corrugated fins make contact with air can be made large compared with the depth of the flat tubes, resulting in improved heat exchange performance. Moreover, as a result of the downwind-side ends of the upwind-side corrugated fins and the upwind-side ends of the downwind-side corrugated fins being kept in contact with ribs formed on the side faces of the flat tubes, it is possible to accurately position the flat tubes, the upwind-side corrugated fins, and the downwind-side corrugated fins, and thereby to reduce assembly errors.

[0008] In the heat exchanger structured as described above, it is preferable that the ribs be continuous in the vertical direction.

[0009] With this structure, it is possible to form the ribs and the flat tubes simultaneously by extrusion.

[0010] In the heat exchanger structured as described above, it is preferable that, as a result of the upwind-side corrugated fins and the downwind-side corrugated fins being kept in contact with the ribs, a predetermined gap be formed between the upwind-side corrugated fins and the downwind-side corrugated fins.

[0011] With this structure, it is possible to efficiently drain defrost water and condensed water through the gap across which the upwind-side corrugated fins and the downwind-side corrugated fins are put together.

Advantages of the Invention

[0012] According to the present invention, it is possible to increase the length over which the corrugated fins make contact with air and thereby to achieve satisfactory heat exchange, and it is possible to accurately position and assemble the flat tubes and the corrugated fins. It is also possible to achieve quick drainage of defrost water and condensed water.

Brief Description of Drawings

[0013]

[Fig. 1] A schematic vertical sectional view showing an outline of the structure of a heat exchanger
 [Fig. 2] A sectional view cut along line A-A in Fig. 1
 [Fig. 3] An enlarged partial horizontal sectional view of the heat exchanger [Fig. 4] A front view of the part shown in Fig. 3 as viewed along line B-B
 [Fig. 5] An enlarged partial horizontal sectional view

similar to Fig. 3 but showing a second embodiment

List of Reference Symbols

[0014]

1	heat exchanger
2, 3	header pipe
4	flat tube
5	refrigerant passage
6	corrugated fin
6U	upwind-side corrugated fin
6D	downwind-side corrugated fin
9	gap
12	rib

Best Mode for Carrying Out the Invention

[0015] Hereinafter, embodiments of the present invention will be described with reference to the accompanying drawings. A heat exchanger 1 has two horizontal header pipes 2 and 3 arranged parallel at an interval from one another in the up/down direction, and has a plurality of vertical flat tubes 4 arranged with a predetermined pitch between the header pipes 2 and 3. The flat tubes 4 are elongate members formed by extrusion of a metal with high thermal conductivity, such as aluminum, and has, formed inside them, refrigerant passages for circulation of refrigerant. As shown in Fig. 3, inside the flat tubes 4 are arranged a plurality of refrigerant passages 5 with an identical cross-sectional shape and an identical cross-sectional area; thus the flat tubes 4 appear to have a cross section like a harmonica. Incidentally, the refrigerant passages 5 need not have a uniform cross-sectional shape and a uniform cross-sectional area, but may have different cross-sectional shapes and different cross-sectional areas.

[0016] The flat tubes 4 are arranged with their extrusion direction vertical, and accordingly the direction of the circulation of refrigerant through the refrigerant passages 5 is vertical. The individual refrigerant passages 5 communicate with the insides of the header pipes 2 and 3. Incidentally, in Fig. 1, the top side of the page is the top side in the vertical direction, and the bottom side of the page is the bottom side in the vertical direction. Between the top-side header pipe 2 and the bottom-side header pipe 3, a plurality of flat tubes 4 are arranged with a predetermined pitch with their length direction vertical.

[0017] The header pipes 2 and 3 and the flat tubes 4 are fixed by welding. Between the flat tubes 4, corrugated fins 6 are arranged, and the flat tubes 4 and the corrugated fins 6 are also fixed by welding. Like the flat tubes 4, the header pipes 2 and 3 and the corrugated fins 6 are formed of a metal with high thermal conductivity (for example, aluminum).

[0018] At one end of the bottom-side header pipes 3, a refrigerant inflow port 7 is provided, and at one end of the top-side header pipes 2, a refrigerant outflow port 8

is provided at a position diagonal to the refrigerant inflow port 7.

[0019] Owing to the structure in which a large number of flat tubes 4 are provided between the header pipes 2 and 3 and corrugated fins 6 are provided between the flat tubes 4, the heat-dissipation (heat-absorption) area of the heat exchanger 1 is large, allowing efficient heat exchange.

[0020] Next, the structure of the corrugated fins 6 will be described with reference to Figs. 2, 3, and 4. In Figs. 2 and 3, the left side of the page is the upwind side, and the right side of the page is the downwind side.

[0021] As shown in Figs. 2 and 3, the corrugated fins 6 divide into upwind-side corrugated fins 6U and downwind-side corrugated fins 6D. The upwind-side corrugated fins 6U have a fin surface with a downward slope toward the downwind side; the downwind-side corrugated fins 6D have a fin surface with an upward slope toward the downwind side. The downward slope of the upwind-side corrugated fins 6U and the upward slope of the downwind-side corrugated fins 6D have the same angle. In the air flow direction, the horizontal direction length of the upwind-side corrugated fins 6U and the horizontal direction length of the downwind-side corrugated fins 6D are equal.

[0022] The downward slope of the upwind-side corrugated fins 6U and the upward slope of the downwind-side corrugated fins 6D do not necessarily have to have the same angle, but may have different angles. The length of the upwind-side corrugated fins 6U and the length of the downwind-side corrugated fins 6D in the air flow direction do not necessarily have to be equal, but may be different.

[0023] Seen from the direction perpendicular to the flow of air, the upwind-side corrugated fins 6U and the downwind-side corrugated fins 6D appear to be a large number of V shapes arranged in the up/down direction. The V shapes here, however, are not closed but open at their bottom part. Specifically, the upwind-side corrugated fins 6U and the downwind-side corrugated fins 6D are not in close contact with each other, but are arranged with a gap 9 secured between them. The gap 9 is so sized as to enable water droplets sticking to the downwind-side ends of the upwind-side corrugated fins 6U and water droplets sticking to the upwind-side ends downwind-side corrugated fins 6D to coalesce.

[0024] On upwind-side ends of the flat tubes 4, ridge-shaped ribs 10U are provided that protrude parallel to the air circulation direction (in other words, toward the upwind side); on downwind-side ends of the flat tubes 4, ridge-shaped ribs 10D are provided that protrude parallel to the air circulation direction (in other words, toward the downwind side). Incidentally, in this embodiment, the ribs 10U and 10D are formed integrally with the flat tubes 4 by extrusion, and extend continuously in the length direction of the vertically arranged flat tubes, from a position slightly lower than the top end of the flat tubes to a position slightly higher than the bottom end of the flat tubes.

[0025] Owing to the fact that, as described above, instead of the ribs 10U and 10D being given the same length as the flat tubes 4, small distances are secured between the top and bottom ends of the flat tubes 4 and the top and bottom ends of the ribs 10U and 10D respectively, the header pipes 2 and 3 only need to have a diameter large enough to receive the body parts of the flat tubes 4, and this helps reduce the diameter of the header pipes 2 and 3 compared with in a case where they need to receive the ribs 10U and 10D as well.

[0026] Incidentally, the upwind-side ends of the upwind-side corrugated fins 6U extend to close to a position flush with the tip ends of the ribs 10U provided on the upwind-side ends of the flat tubes 4 (in this embodiment, the upwind-side ends of the upwind-side corrugated fins 6U are approximately flush with tip ends of the ribs 10U), and the downwind-side ends of the downwind-side corrugated fins 6D extend to close to a position flush with the tip ends of the ribs 10D provided on the downwind-side ends of the flat tubes 4 (in this embodiment, the downwind-side ends of the downwind-side corrugated fins 6D are approximately flush with the tip ends of the ribs 10D).

[0027] Instead of the structure described above in which the upwind-side ends of the upwind-side corrugated fins 6U are flush with the tip ends of the ribs 10U and the downwind-side ends of the downwind-side corrugated fins 6D are flush with (level with) the tip ends of the ribs 10D, it is also possible to adopt a structure in which the upwind-side ends of the upwind-side corrugated fins 6U do not reach a position flush with the tip ends of the ribs 10U and the downwind-side ends of the downwind-side corrugated fins 6D do not reach a position flush with the tip ends of the ribs 10D, or a structure in which the upwind-side ends of the upwind-side corrugated fins 6U extend beyond a position flush with the tip ends of the ribs 10U and the downwind-side ends of the downwind-side corrugated fins 6D extend beyond a position flush with the tip ends of the ribs 10D. These structures may be combined together in any way.

[0028] As seen from the front, the width of the ribs 10U and 10D is smaller than the width of the flat tubes 4. Thus, between the ribs 10U and the upwind-side corrugated fins 6U, gaps are left, and these gaps form vertical drain grooves 11U. Likewise, between the ribs 10D and the downwind-side corrugated fins, gaps are left, and these gaps form vertical drain grooves 11D.

[0029] On the side faces of the flat tubes 4, at their center, ribs 12 are formed that are continuous in the length direction of the flat tubes 4 (in this embodiment, the vertical direction). The downwind-side ends of the upwind-side corrugated fins 6U and the upwind-side ends of the downwind-side corrugated fins 6D are kept in contact with these ribs 12. Thus a gap 9 is formed that has a width equal to the thickness of the ribs 12. The ribs 12 also are formed integrally with the flat tubes 4 by extrusion, and are continuous, in the length direction of the vertically arranged flat tubes, from a position slightly low-

er than the flat tube top ends to a position slightly higher than the flat tube bottom ends. This eliminates the need to form, in the header pipes 2 and 3, openings in which to insert the ribs 12, and makes simple the process of forming, in the header pipes 2 and 3, openings in which to insert the flat tubes 4.

[0030] The position of the ribs 12 does not necessarily have to be coincident with the position of the center of the side faces of the flat tubes 4, but may be displaced from it. In this case, if the upwind-side corrugated fins 6U and the downwind-side corrugated fins 6D need be located within the width of the flat tubes 4 in the air flow direction, their respective lengths in the air flow direction are adjusted. If they may extend out of the width of the flat tubes 4 in the air flow direction, their respective lengths in the air flow direction may be equal to or different from each other.

[0031] Although in this embodiment the ribs 12 are formed continuous in the vertical direction, they may instead be each formed of discrete parts, or may be provided only at several places (for example, at a total of three places corresponding to a top, a middle, and a bottom part of the corrugated fins, or at a total of two places corresponding to a top and a bottom part of the corrugated fins). Possible ways of forming such discontinuous ribs 12 include: fitting ribs 12 as separate parts to the body of the flat tubes by welding; machine-removing desired parts of continuous ribs 12 formed integrally with the flat tubes 4; and machine-cutting part of the flat tubes 4 into ribs.

[0032] When refrigerant is passed through the heat exchanger 1 while air is circulated with an unillustrated fan, in an operation mode in which the heat exchanger 1 is used as an evaporator (for example, when heating operation is performed by use of the heat exchanger 1 in the outdoor unit of a separate-type air conditioner comprising an indoor unit and an outdoor unit, the heat exchanger 1 acts as an evaporator), the heat exchanger 1 absorbs heat from the air, and in return releases cold into the air. Since the upwind-side corrugated fins 6U and the downwind-side corrugated fins 6D each have a sloped fin surface, compared with in a case where corrugated fins have no slope and are arranged horizontally, the corrugated fins 6 as a whole extend longer in the air flow direction, achieving high heat exchange performance.

[0033] As operation that absorbs heat from the air continues, on the surface of the upwind-side corrugated fins 6U, on the surface of the downwind-side corrugated fins 6D, and also on the surface of the flat tubes 4, moisture in the air condenses. Initially fine water droplets combine into larger water droplets, which are then drained through the upwind-side drain grooves 11U and the downwind-side drain grooves 11D of the flat tubes 4. At these places, a flow of air prompts the breaking of the surface tension of water; thus the so-called bridging phenomenon in which water forms a film by its surface tension is unlikely to occur, and water can be made to flow out quickly.

[0034] Part of the water droplets flow down along the

slanted surfaces of the upwind-side corrugated fins 6U or the downwind-side corrugated fins 6D, and meet at the gap 9. The gap 9 is so sized as to enable water droplet sticking to the downwind-side ends of the upwind-side corrugated fins 6U and water droplets sticking to the upwind-side ends of the downwind-side corrugated fins 6D to coalesce; thus, when water droplets on the upwind-side corrugated fins 6U and water droplets on the downwind-side corrugated fins 6D meet at the gap 9, they break each other's surface tension and coalesce, and flow out quickly through the gap 9 without causing the bridging phenomenon.

[0035] In an operation mode in which the heat exchanger 1 is used as an evaporator (an operation mode in which the heat exchanger 1 absorbs heat from the outdoor air), depending on the ambient air temperature condition and the operation condition, moisture in the air may, in the form of frost, stick to the surface of the flat tubes 4 and the corrugated fins 6. As time passes, frost gets thicker and lowers heat exchange performance; thus it is necessary to perform, from time to time, defrosting operation, in which the heat exchanger 1 is turned to a condenser, to melt frost. Like condensed water, defrost water resulting from frost melting also is drained smoothly through the drain grooves 11U and 11D and the gap 9. Thus, on return from defrosting operation to normal operation, it will not occur that water droplets that have remained without being drained freeze and impair heat exchange performance. In this way, it is also possible to achieve an object of smoothly draining defrost water and condensed water.

[0036] When the upwind-side corrugated fins 6U and the downwind-side corrugated fins 6D are welded to the flat tubes 4, by keeping the downwind-side ends of the upwind-side corrugated fins 6U and the upwind-side ends of the downwind-side corrugated fins 6D in contact with the ribs 12 on the side faces of the flat tubes 4, it is possible to accurately position the flat tubes 4, the upwind-side corrugated fins 6U, and the downwind-side corrugated fins 6D, and to reduce assembly errors. Production efficiency is also improved.

[0037] The downward slope of the upwind-side corrugated fins 6U and the upward slope of the downwind-side corrugated fins 6D can be selected within the range of 5° to 40°. The sharper the slope, the larger the heat exchange area and thus the easier it is to drain, but the higher the resistance to the circulation of air. It is therefore advisable to set the angle at an appropriate value through experiments. Other relevant dimensions are as follows: the interval between the flat tubes 4 is 5.5 mm; the thickness of the flat tubes 4 is 1.3 mm; in the air flow direction, the horizontal direction length of both the upwind-side corrugated fins 6U and the downwind-side corrugated fins 6D is 18 mm; the ridge-valley pitch of both the upwind-side corrugated fins 6U and the downwind-side corrugated fins 6D is 2 mm to 3 mm; the size of the gap 9 is 0.5 mm at the maximum. Needless to say, these values are merely examples, and are not meant to limit the contents

of the invention. For example, since the gap 9 has simply to be so sized as to enable water droplets sticking to the downwind-side ends of the upwind-side corrugated fins 6U and water droplets sticking to the upwind-side ends of the downwind-side corrugated fins 6D to coalesce, its size can be set within the range up to 4 mm at the maximum.

[0038] A second embodiment of the present invention is shown in Fig. 5. In the first embodiment, since the thickness of the ribs 12 is just as large as the width of the gap 9, to give the gap 9 a size of 0.5 mm at the maximum, the ribs 12 need to be given a thickness of 0.5 mm or less. In the second embodiment, in downwind-side corners of the upwind-side corrugated fins 6U and in upwind-side corners of the downwind-side corrugated fins 6D, cuts 13 are formed that receive the ribs 12. This makes it possible to give the gap 9 a width smaller than the thickness of the ribs 12. Thus, even when, for reasons associated with mold production, the ribs 12 have a large thickness, it is possible to give the gap 9 such a size as to enable water droplets sticking to the downwind-side ends of the upwind-side corrugated fins 6U and water droplets sticking to the upwind-side ends of the downwind-side corrugated fins 6D to coalesce.

[0039] Incidentally, the ribs 12 are easier to form by extrusion when they have a thickness that is large to a certain degree (for example, 2 mm). In a case where the gap 9 can be made large (for example, 2 mm), the thickness of the ribs 12 can itself be made use of, and thus there is no need to form cuts 13.

[0040] The embodiments by way of which the present invention has been described above are not meant to limit the scope of the present invention; the present invention may be implemented with many modifications and variations made within the spirit of the invention.

Industrial Applicability

[0041] The present invention finds wide application in parallel-flow-type heat exchangers.

Claims

1. A heat exchanger comprising:

a plurality of horizontal header pipes arranged parallel at an interval from one another;
a plurality of vertical flat tubes arranged with a predetermined pitch between the plurality of header pipes, with vertical refrigerant passages provided inside the flat tubes communicating with insides of the header pipes; and
corrugated fins arranged between the flat tubes, wherein
the corrugated fins comprise
upwind-side corrugated fins whose fin surface has a downward slope toward a downwind side

and

downwind-side corrugated fins whose fin surface has an upward slope toward the downwind side, and

downwind-side ends of the upwind-side corrugated fins and upwind-side ends of the downwind-side corrugated fins are kept in contact with ribs formed on side faces of the flat tubes.

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2. The heat exchanger according to claim 1, wherein the ribs are continuous in a vertical direction.

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3. The heat exchanger according to claim 1 or 2, wherein, as a result of the upwind-side corrugated fins and the downwind-side corrugated fins being kept in contact with the ribs, a predetermined gap is formed between the upwind-side corrugated fins and the downwind-side corrugated fins.

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FIG.1

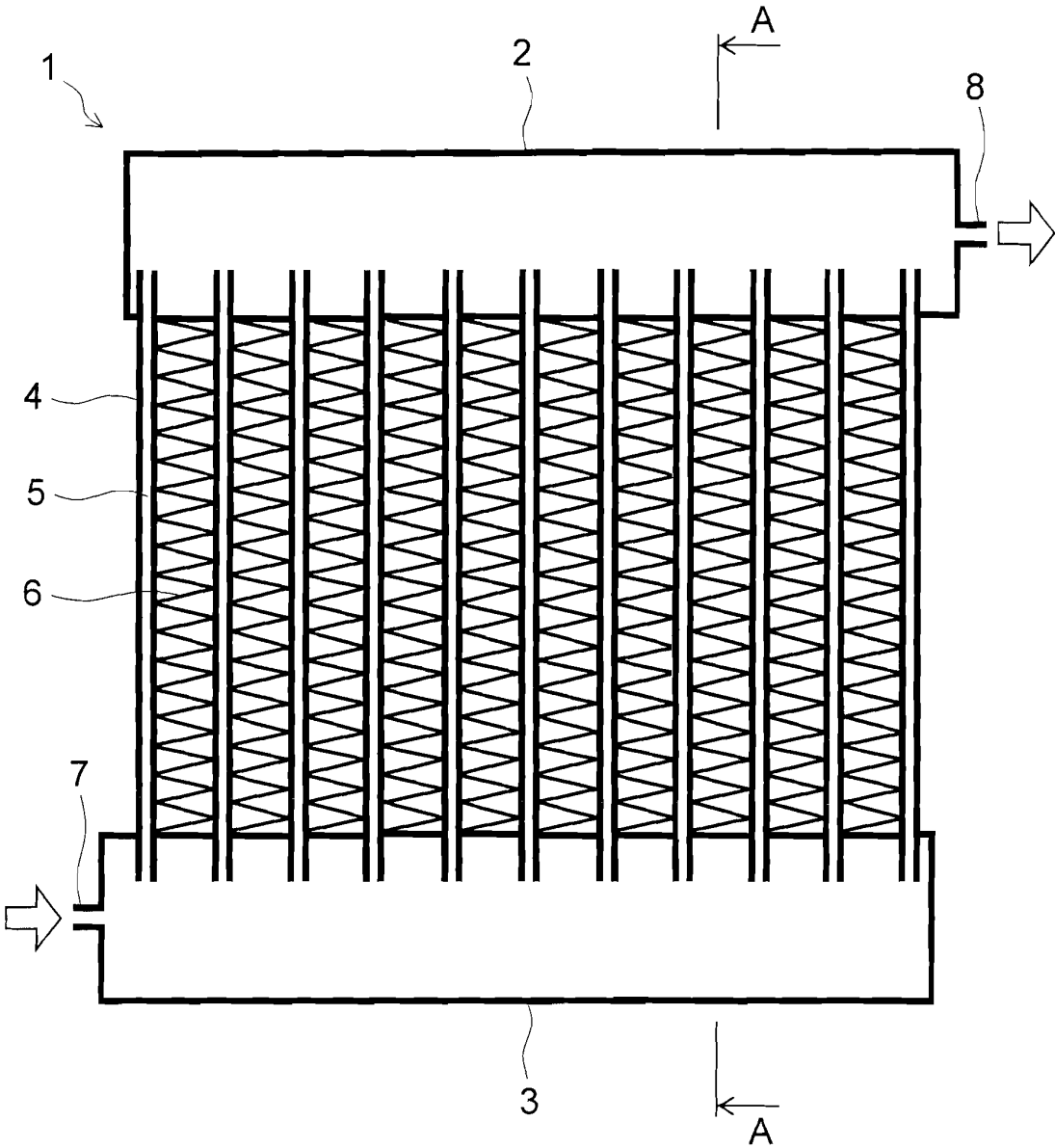


FIG.2

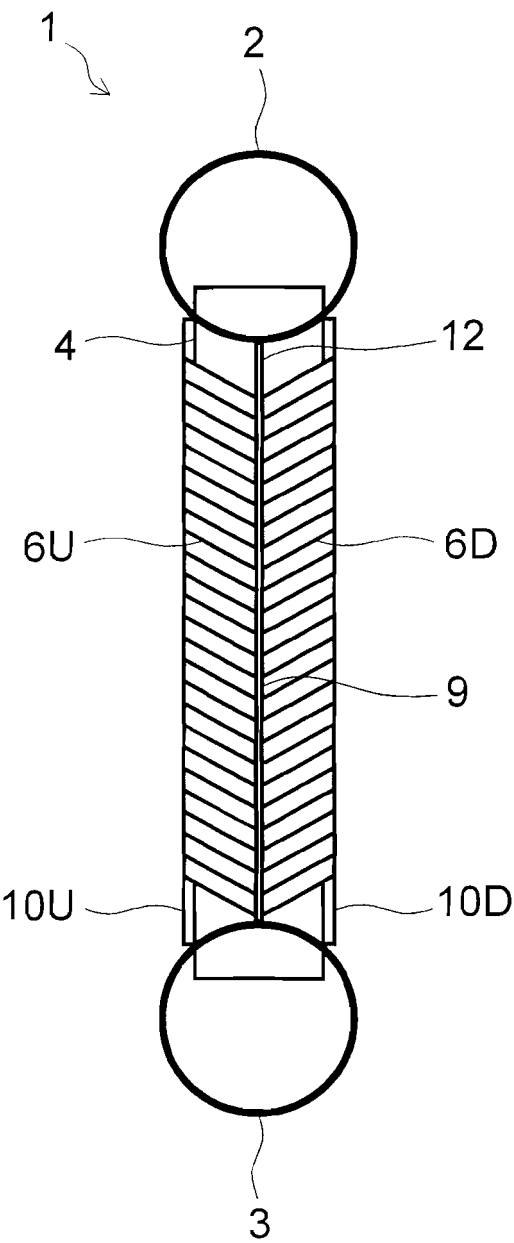


FIG.3

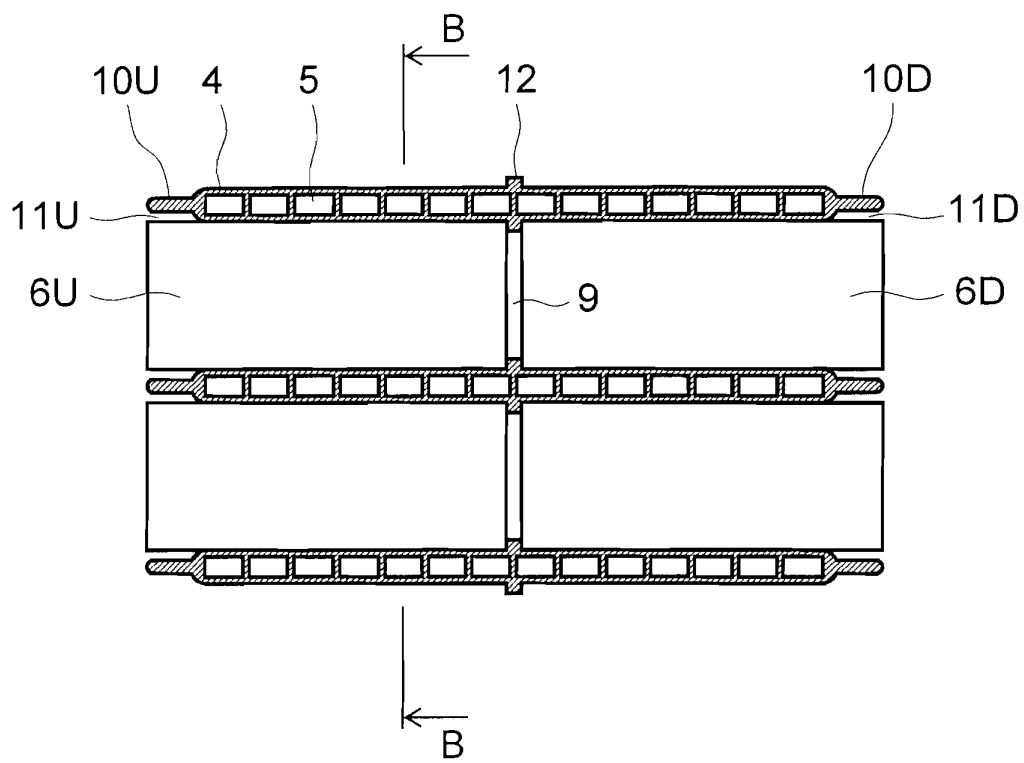


FIG.4

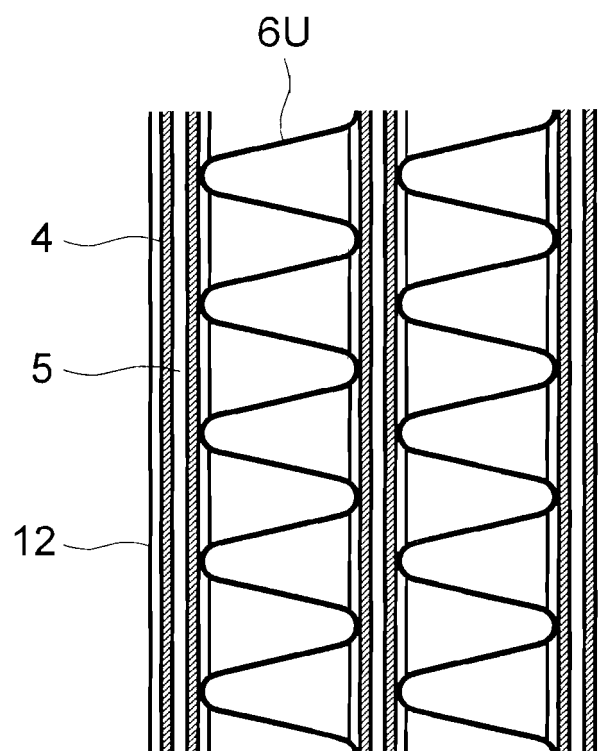
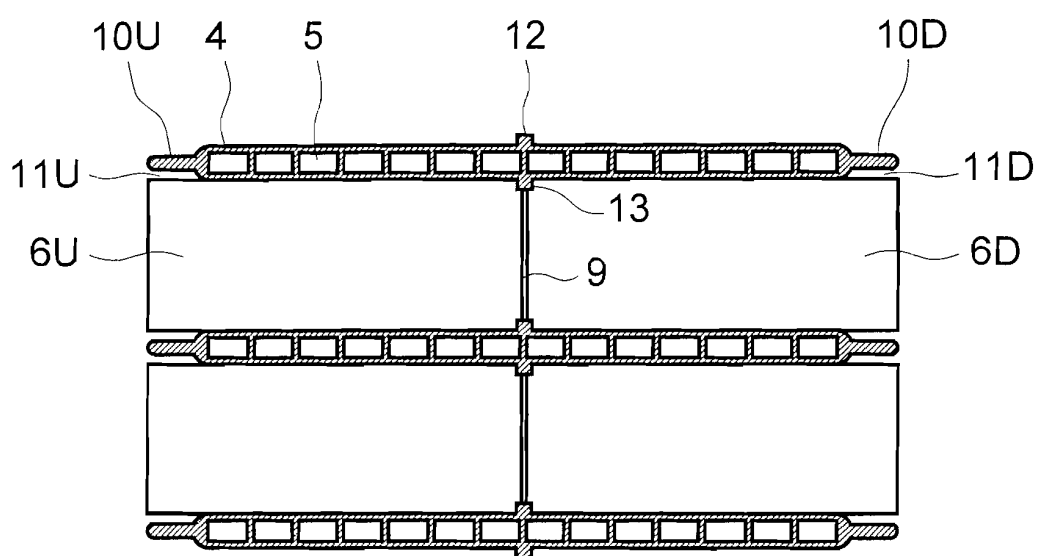


FIG.5



INTERNATIONAL SEARCH REPORT

International application No.

PCT/JP2008/063948

A. CLASSIFICATION OF SUBJECT MATTER

F28F1/30 (2006.01) i, F25B39/02 (2006.01) i

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

F28F1/30, F25B39/02

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Jitsuyo Shinan Koho	1922-1996	Jitsuyo Shinan Toroku Koho	1996-2008
Kokai Jitsuyo Shinan Koho	1971-2008	Toroku Jitsuyo Shinan Koho	1994-2008

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	JP 2005-24187 A (Matsushita Electric Industrial Co., Ltd.), 27 January, 2005 (27.01.05), Par. Nos. [0013] to [0022]; Figs. 1, 3 (Family: none)	1-3
Y	JP 2002-257433 A (Toyo Radiator Co., Ltd.), 11 September, 2002 (11.09.02), Par. Nos. [0006] to [0009]; Figs. 1, 2 (Family: none)	1-3

☒ Further documents are listed in the continuation of Box C.☐ See patent family annex.

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Date of the actual completion of the international search
19 August, 2008 (19.08.08)Date of mailing of the international search report
26 August, 2008 (26.08.08)Name and mailing address of the ISA/
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INTERNATIONAL SEARCH REPORT

International application No.

PCT/JP2008/063948

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT		
Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	JP 2002-213889 A (Modine Manufacturing Co.), 31 July, 2002 (31.07.02), Par. Nos. [0024] to [0033]; Figs. 1 to 7 & US 6397939 B1 & EP 1215461 A2 & AU 8939501 A & BR 105350 A & CA 2364163 A & TW 526324 B & KR 10-2002-0046930 A & CN 1366169 A	1-3

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REFERENCES CITED IN THE DESCRIPTION

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Patent documents cited in the description

- JP 2005024187 A [0004]
- JP 2001066083 A [0004]